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Effects of climate and geochemistry on soil organic matter stabilization and greenhouse gas emissions along altitudinal transects in different mountain regions

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Terrestrial ecosystems are strongly influenced by climate change and soils are key compartments of the global carbon (C) cycle in terms of their potential to store or release significant amounts of C. This study is part of the interregional IAEA Technical Cooperation Project “Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions (INT5153)” aiming to improve the understanding of climate change impacts on soil organic carbon (SOC) in fragile polar and high mountainous ecosystems at local and global scale for their better management and conservation.

The project includes 13 benchmark sites situated around the world. Here we present novel data from altitudinal transects of three different mountain regions (Mount Kilimanjaro, Tanzania; Mount Gongga, China; Cordillera Blanca, Peru). All altitudinal transects cover a wide range of natural ecosystems under different climates and soil geochemistry. Bulk soil samples (four field replicates per ecosystem) were subjected to a combination of aggregate and particle-size fractionation followed by organic C, total nitrogen, stable isotope (^{13}C, ^{15}N) and radiocarbon (^{14}C) analyses of all fractions. Bulk soils were further characterized for their geochemistry (Na, K, Ca, Mg, Al, Fe, Mn, Si, P) and incubated for 63 days to assess greenhouse gas emissions (CO_2, CH_4, NO, N_2O). Further, stable C isotopic signature of CO_2 was measured to determine the isotopic signature of soil respiration (using Keeling plots) and to estimate potential respiration sources.

The following four ecosystems were sampled at an altitudinal transect on the (wet) southern slopes of Mount Kilimanjaro: savannah (920m), lower montane rain forests with angiosperm trees (2020m), upper montane cloud forest with gymnosperm trees (2680m), subalpine heathlands (3660m). Both forests showed highest C contents followed by subalpine and savannah. The largest part of SOC was found in particulate organic matter followed by microaggregates, except for the subalpine ecosystem which had most SOC stored in microaggregates. Silt and clay fractions stored the smallest fraction of SOC for all ecosystems. Cumulative soil CO_2 emissions (normalized to SOC, g_{CO2}-Ckg^{-1}_{SOC}) after 63 days of incubation were highest for savannah (15.2 $\pm$ 1.4) followed by subalpine (7.9 $\pm$ 0.5), upper forest (6.9 $\pm$ 1.0) and lower forest (4.8 $\pm$ 0.4). CO_2 emissions were negatively correlated with soil C contents, showing that soils with lower C contents loose higher relative amounts of their SOC through soil respiration. Keeling plot intercept is a measure for the isotopic signature of respired CO_2 and high offsets between Keeling plot intercepts and the isotopic signature of bulk SOC point towards labile (^{13}C-depleted) SOC fractions as respiration sources. Highest offsets (and thus most labile respiration sources) were observed for savannah followed by subalpine, lower forest and upper forest and these were positively correlated with cumulative CO_2 emissions, showing that in savannah soils, which have lowest C contents and respire highest amounts of CO_2, mainly labile SOC is used as respiration source.

Results from the other two altitudinal transects are currently under investigation and will be presented in conjunction with climatic and geochemical data.